

## CHAPTER 8

# Using Nutrient Criteria To Protect Water Quality

- A. State Water Quality Standards
- B. Water Quality–Based Approach to Pollution Control
- C. Nonpoint Source Pollution Control
- D. Comprehensive Nutrient Management
- E. Resources

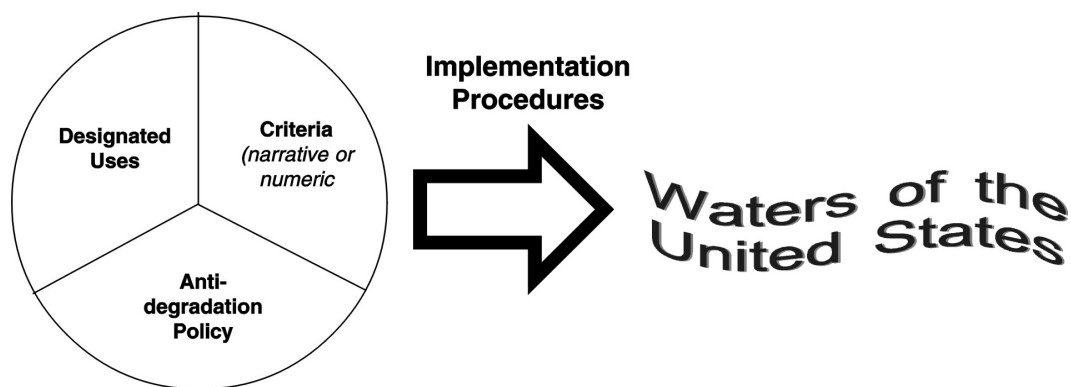
This chapter provides an introduction to the applications of nutrient criteria. Chapter 1 described the uses of nutrient criteria as (1) identification of problems, (2) management planning, (3) regulatory assessments, (4) project evaluations, and (5) status and trend determination of the water resource. In this chapter, added discussion is provided for some of these uses of criteria. Sections A and B address regulatory assessments in the context of standards development and the water quality–based approach to pollution control, including development of a total maximum daily load (TMDL) and National Pollution Discharge Elimination System (NPDES) permits. Section C focuses exclusively on nonpoint source management programs. The chapter text ends with Section D, which addresses a comprehensive planning, application, and evaluation procedure for effective lake and reservoir nutrient quality management. Section E is a descriptive listing of some useful information resources associated with lake and watershed management.

### A. State Water Quality Standards

#### *1. Water Quality Standards and the Clean Water Act*

The goals of the Clean Water Act (CWA) are to achieve, wherever attainable, water quality that provides for protection and propagation of fish, shellfish, and wildlife and recreation in and on the water. The CWA further specifies that States adopt, and EPA review, standards consisting of designated uses and criteria based on those uses that serve the purpose of the CWA. EPA’s implementing regulations require States to specify designated uses for their waters and consideration of the goals of the CWA described above. Furthermore, States must adopt water quality criteria that protect the designated uses. Criteria must be based on sound scientific rationale and must contain sufficient parameters or constituents to protect the designated uses. For waters with multiple use designations, criteria must support the most sensitive use. Finally, in designating uses and establishing water quality criteria, States must ensure attainment of standards in downstream waters. With regard to nutrient criteria, Section 304(a) of the CWA directs EPA to develop and publish criteria that reflect the latest scientific knowledge of the effects of pollutants on biological community diversity, productivity, and stability, including information on the factors affecting rates of eutrophication for varying types of receiving waters. In its implementing regulation, EPA recommends that States adopt water quality criteria to protect designated uses based on Section 304(a) criteria, Section 304(a) criteria modified to reflect site-specific conditions, or criteria based on other scientifically defensible methods.

As illustrated in Figure 8.1, water quality standards for waters of the United States comprise designated uses, criteria to protect those uses, an antidegradation policy to maintain existing water quality, and implementation procedures for application to specific waters. Once water quality standards are adopted and approved, they become the basis for legally enforceable source control. Criteria as a component of standards are always established in the context of a designated use. Therefore, EPA, as well as States and Tribes, must develop criteria that are directly applicable to designated uses.



**Figure 8.1. Components of water quality standards.**

## ***2. Protecting Designated Uses***

It has been amply demonstrated that nutrients are a major contributor to use impairment in waters of the United States. Because States are required to designate uses in consideration of the goals of the CWA and adopt criteria that contain sufficient parameters or constituents to protect designated uses, and because it is EPA’s responsibility to provide recommended criteria, the Agency must develop and publish Section 304(a) criteria for nutrients that provide for protection and propagation of fish, shellfish, and wildlife and recreation in and on the water. Furthermore, EPA’s Section 304(a) criteria should reflect the effects on biological community diversity, productivity, and stability.

EPA’s Section 304(a) criteria will be issued on the basis of ecoregion and water body type. This approach to nutrient criteria development not only meets the above requirements but also provides a sound scientifically defensible approach that accounts for the characteristics of different types and locations of water bodies. EPA’s ecoregional nutrient criteria are intended to represent enrichment conditions of surface waters that are minimally impacted by human development activities, and will be developed and further refined based on the five elements described in this technical guidance manual. Water quality criteria incorporating minimally impacted (i.e., reference) conditions should provide for protection and propagation of aquatic life and recreation, and reflect conditions that will not adversely affect the biological community. Both causal variables (e.g., TN and TP) and response variables (e.g., turbidity and chlorophyll *a*) are necessary to provide sufficient protection of these uses before impairment occurs and to maintain downstream uses.

## ***3. Maintaining Existing Water Quality***

In addition to adopting sufficient criteria to protect designated uses for their waters, States and authorized Tribes must also adopt and implement an antidegradation policy to maintain existing uses and to maintain high water quality where it exists—regardless of the specified designated uses and associated criteria. State and Tribal antidegradation policies must be consistent with the Federal antidegradation policy as described at 40 CFR 131.12 to gain approval from EPA. Two key provisions of the Federal antidegradation policy are relevant to this discussion. The first requires that the level of water quality necessary to protect the existing uses must be maintained and protected (“Tier 1”). For a variety of reasons, an existing use may differ from the designated use, and may require either less stringent or more stringent protection than afforded by the criteria intended to protect the designated use.

The “Tier 2” provision is intended to provide protection for existing uses in cases where waters are not meeting their designated use, and also where the existing use happens to be better than the designated use. This second provision requires that existing high-quality waters (i.e., water quality that exceeds criteria to protect “fishable and swimmable” uses) must be maintained and protected unless it is demonstrated through a public process that a lowering of water quality is necessary to accommodate important economic or social development. In lowering water quality, the existing uses (Tier 1) must still be fully protected. “Tier 3” of the antidegradation policy preserves outstanding national resource waters, which is the highest level of protection under this policy.

As nutrient criteria are developed and adopted, it is important that States also review their antidegradation policy and associated implementation procedures. Antidegradation requirements are typically triggered when an activity is proposed that may have some effect on existing water quality. These requirements apply at a minimum to activities regulated under State, Tribal, or Federal law but can be more broadly applied. In practice, States and Tribes may encounter water where existing uses may not be protected by adopted criteria or existing high water quality exceeds adopted criteria. Antidegradation policies and procedures must ensure public participation in decisions affecting, for example, the impact on unique lakes of higher relative nutrient quality than might be stipulated in State or regional nutrient criteria based on a more extensive data set. States and Tribes should have effective antidegradation implementation procedures in place with criteria to ensure that existing water quality is maintained and protected from degradation by existing future point and nonpoint sources. Any State or local nonpoint source control requirements should be included in an antidegradation review.

#### ***4. Providing Flexibility in Implementation***

Abundant flexibility is built into the criteria setting process and water quality standard regulation to allow States to (1) develop their own criteria to protect specific uses or reflect more locally representative conditions, (2) use different techniques to develop criteria as long as they are protective and scientifically defensible, and (3) conduct use attainability studies and refine their use designation, where there is a conflict between designated uses and ecological criteria.

States also have the flexibility to adopt numeric criteria to protect designated uses or to adopt methods and procedures that translate narrative criteria to protect designated uses. Narrative criteria statements, often referred to as “general criteria” in States’ standards regulations, usually take the form of a description of desired water quality condition or a preclusion of certain types of pollution or undesirable conditions (i.e., the “free from” provisions).

Narrative criteria are considered to be critical backstops for designated use protection and are a powerful means of achieving desired water quality if they are interpreted in a clear and consistent manner. In water quality standards, a “translator” identifies a process, methodology, or guidance that States or Tribes will use to quantitatively interpret narrative criteria statements. Translators may consist of biological assessment methods (e.g., field measures of the biological community), biological monitoring methods (e.g., laboratory toxicity tests), models or formulate that uses input of site-specific information/data or other scientifically defensible methods. Translators are particularly useful for addressing water quality conditions that require a greater degree of sophistication to assess than can be typically expressed by numerical criteria that apply broadly to all waters with a given use designation. The translator may be either directly incorporated into State or Tribal water quality standards or incorporated by reference. In either case, specific limits or values for a measurable pollutant derived using a translator that interpret a narrative criterion statement should be attached to the State or Tribal regulations to ensure public review, as would be required of any site-specific numerical criterion.

The existing water quality standards regulation, along with the associated policies and national guidance, can provide the flexibility needed to accommodate appropriate adoption of nutrient criteria and subsequent implementation of control measures. The negative consequences of adopting inappropriate criteria include cases where the adopted criteria (and ensuing permit limits or other control measures) are not stringent enough and result in a loss of use, and cases where the adopted criteria are too stringent and lead to unnecessary source controls and increases to the list of impaired waters. In specific situations where criteria are thought to be overly protective, regulatory alternatives such as refined use designation, site-specific criteria, or a variance could be employed to ensure that the appropriate uses and criteria to protect the uses are established. For example, if a regulated source faces expensive treatment to comply with a new or revised requirement, the State or Tribe could seek a variance as described in 40 CFR 131.10(g) and determine if site-specific criteria are appropriate.

Specific situations where nutrient criteria are not sufficient to protect uses may be remedied through development of site-specific criteria, the need for which could be identified through an antidegradation review in situations involving high-quality water (i.e., nutrient concentrations below criteria levels). In situations where uses are not attained, the TMDL process is intended to improve water quality to meet the designated use. In situations involving high-quality water, new or expanded nutrient loads from a regulated source will probably trigger an antidegradation review. In addition to determining whether lowering water quality is necessary to accommodate important economic or social development, information generated through this review could be used to derive appropriate site-specific criteria to protect uses.

Water quality criteria published by EPA under Section 304(a) of the CWA such as criteria for nutrients serve as primary sources of information to States and Tribes as they develop numeric criteria as part of their State or Tribal water quality standards. Under the CWA and EPA's implementing regulations, States and Tribes may also use other information, including local water quality conditions, as they develop State or Tribal standards. In addition, EPA typically uses EPA's water quality criteria as the principal basis for proposing and promulgation of a replacement water quality standard where a State or Tribe fails to adopt an acceptable standard. Where a State or Tribe does not adopt scientifically defensible nutrient criteria to protect designated and existing uses, EPA will, as necessary, propose to promulgate Federal water quality standards for State or Tribal waters. In doing so, EPA commits to a process that includes public review and comment. EPA will solicit data information from the public to determine if such proposed Federal nutrient criteria for State waters are sufficiently protective of uses. This public process will help ensure that promulgated Federal water quality standards are neither too stringent nor overly permissive.

## **B. Water Quality–Based Approach to Pollution Control**

The water quality–based approach to watershed management emphasizes the overall quality of water within a watershed and provides a mechanism through which the amount of pollutant entering the water body is controlled based on the intrinsic conditions of the body of water and the standards set to protect it. A fundamental step in implementing the water quality–based approach is establishing procedures to assess attainment of water quality standards. With respect to nutrient criteria, States should identify and adopt, as appropriate, procedures for determining the attainment status that address factors such as:

- Monitoring strategy
- Spatial and temporal extent of sampling
- Frequency and duration of exceeding nutrient criteria parameters (e.g., TN, TP, chlorophyll *a*, algal turbidity)

- Minimum number of samples required
- Averaging period for combining samples to compare to nutrient criteria parameters.

Additional discussion of parameters to sample, sampling frequency, and sampling locations is provided in sections B.3 and B.10 of this chapter. These procedures should lend themselves to be reproducible, apply consistently to the waters where the criteria are assigned to protect the designated use, and provide clear answers to the following questions:

- What parameters do I monitor?
- Where and when do I sample?
- How do I evaluate the results?

The information below summarizes how the different programs fit into an overall water quality control scheme and is not intended as specific implementation guidance. Implementation of a program should be consistent with the specific programmatic regulations and guidance documents provided by the program office.

### ***Step 1: Identification of Impaired and Threatened Waters***

Step 1 of the water quality–based approach to watershed management encompasses two CWA requirements: 305(b) reporting and development of a 303(d) list. Both of these activities are separate CWA elements and EPA programs. They are cited here to illustrate their application to components of a comprehensive coordinated EPA effort to improve the Nation’s water quality.

#### **■ 305(b) Water Quality Inventory**

The CWA establishes a process for States to develop information on the quality of the Nation’s water resources in Sections 106(e), 204(a), 303(d), 305(b), and 314(a). Under Section 305(b), each State or Tribe must develop a program to monitor the quality of its surface and ground waters. The primary purpose of the State monitoring program is to evaluate attainment with water quality standards. Section 305(b) requires States to provide EPA with a report describing the status of water quality every 2 years.

Lake water quality assessment is an integral part of a State 305(b) report. States should report summary statistics for use support and for causes and sources of impairment of lakes as described in the most recent *Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305(b) Reports) and Electronic Updates*. For all assessed lakes, States are required to include statistics on the degree of use support (fully supporting, threatened, or impaired), the degree of use support organized by use (e.g., aquatic life, swimming), and the total size of waters impaired by various source categories (e.g., industrial point sources, silviculture).

The role of nutrient criteria in the 305(b) process is that nutrient criteria establish the benchmark used to judge the degree of use support and are, therefore, an integral part of the assessment and 305(b) reporting process. In particular, for significant publicly owned lakes, each State should include in its 305(b) report a discussion of State water quality standards as they apply to lakes. Nutrient criteria that have been adopted into State water quality standards are an important component of this discussion. If nutrient criteria have been developed, but have not yet been adopted into State water quality standards, they could still be utilized to classify the trophic status of the lake and discussed in the context of a measure used to determine lake status, rather than as a water quality standard (see CWA Section 314(a)(1)(E)).

## ■ Section 303(d) Lists

Section 303(d)(1)(A) of the CWA established the requirement for the development of Section 303(d) lists of impaired waters. The Section 303(d) list is a prioritized list of water quality limited waters and identifies waters needing TMDLs. States prepare their 303(d) lists using the information contained in their 305(b) reports, as well as other existing and readily available sources of water quality information. States, Territories, and authorized Tribes must submit their 303(d) lists to EPA for review and approval. If EPA disapproves a Section 303(d) list, then EPA will establish a Section 303(d) list for them.

### *Step 2: Priority Ranking and Targeting*

Once water bodies needing TMDLs have been identified on the 303(d) list, a State, Territory, or authorized Tribe should prioritize those water bodies using established ranking procedures that consider all water pollution control activities within the State, Territory, or lands of the authorized Tribe. The CWA states that the “State shall establish a priority ranking for such waters.” The goal of priority ranking is to focus attention on the right water bodies at the right time, while enabling a State, Territory, or authorized Tribe to make efficient use of its available resources and meet the objectives of the CWA.

In addition to priority ranking the waters on the 303(d) list, States, Territories, and authorized Tribes must develop a schedule for establishing TMDLs. The schedule is not intended to rigidly constrain the process of establishing TMDLs and should be considered an opportunity to explain how TMDLs will be completed. When synchronized with the broader planning process of a State, Territory, or authorized Tribe, the schedule can be the basis for a practical plan for managing and completing the required TMDLs.

### *Step 3: Development of TMDLs*

TMDLs are written plans and analyses established to ensure that the water bodies will attain and maintain water quality standards. The TMDL process is an essential element of the water quality-based approach to watershed management. It links development and implementation of control measures to attainment of water quality standards. Through establishment and implementation of a TMDL, pollutant loadings from all sources are estimated, links are established between pollutants and sources, and appropriate control mechanisms can be established or modified so that water quality standards can be achieved.

Successful use of the TMDL process to develop an effective strategy to improve water quality requires accurately defining the problem, characterizing the impaired water body and all pollutants contributing to the impairment, and understanding the political and economic constraints that affect implementation and acceptance of the TMDL. Establishment of TMDLs rests on the following premises:

- The total pollutant load to a water body is derived from point, nonpoint, and background sources.
- Pollutant loads can be transported into a water body directly through effluent discharge, bank and bar erosion (in streams, river, estuaries, and lakes), recirculation (e.g., nutrients in lakes, estuaries, and wetlands), solar heating, atmospheric deposition, and ground water flows or indirectly by overland flow caused by snowmelt or precipitation.

- The technical approach used to develop the TMDL will vary according to the nature of the problem, pollutant of concern, type of water body, types and number of pollutant sources, and political and economic constraints that affect a specific watershed.

An essential step in developing a TMDL is determining the water body target for the pollutant of concern. From a broad management perspective, the purpose of target analysis is to define the relationship between designated uses, numeric measure(s) of success, and pollutant. The primary goals of target analysis are to (1) clarify whether the ultimate objective of the TMDL is to comply with a numeric water quality criterion, comply with an interpretation of a narrative water quality criterion, or attain a desired condition that supports meeting a specified designated use; (2) identify the water body's critical conditions; (3) identify appropriate ways to measure progress toward achieving stated goals; and (4) tie the measures to pollutant loading.

The criteria development process described in this guidance manual provides the necessary information to complete the target analysis component of a TMDL.

#### ***Step 4: Implementation of Controls***

TMDLs are required to consider the effects of processes that contribute pollutants to a water body. These processes may relate to thermal discharges, critical flow conditions, sedimentation, and riparian and channel processes. Control measures to implement TMDLs, therefore, are not limited to NPDES permits, but also may include State, Territorial, Tribal, and local authorities and actions to reduce nonpoint source pollution.

#### **■ NPDES Permits**

The CWA requires waste water dischargers to have a permit establishing pollution limits, and specifying monitoring and reporting requirements. More than 200,000 sources are regulated by NPDES permits nationwide. NPDES permits regulate household and industrial wastes that are collected in sewers and treated at municipal waste water treatment plants. Permits also regulate industrial point sources and concentrated animal feeding operations that discharge into other waste water collection systems, or that have the potential to discharge directly into receiving waters. Permits regulate discharges with the goals of (1) protecting public health and aquatic life and (2) ensuring that every facility treats waste water. Typical pollutants regulated by NPDES are “conventional pollutants” such as fecal coliforms or oil and grease from the sanitary wastes of households, businesses, and industries, and “toxic pollutants” including pesticides, solvents, polychlorinated biphenyls, dioxins, and heavy metals that are particularly harmful to animal or plant life. “Nonconventional pollutants” are any additional substances that are not conventional or toxic that may require regulation, including nutrients such as nitrogen and phosphorus.

Discharge monitoring data for pollutants limited and/or monitored pursuant to NPDES permits issued by States, Tribes, or EPA are required to be stored in the central EPA Permit Compliance System (PCS). Assessment of point source loadings is not a simple process of assessing PCS data, even though PCS is an important data source. The PCS database does not provide complete information for important nitrogen sources. Most PCS nitrogen data are generated by water quality–based permit limitations on ammonia, often applied in discharges to smaller streams. Few data exist in PCS on other forms of nitrogen, or TN; and data for TP are not frequently found in PCS. This situation exists largely because most permits do not include limits and/or monitoring requirements for nitrogen or phosphorus. The lack

of nutrient limits and/or monitoring requirements in permits is due to a general lack of State water quality standards for these parameters.

### ■ NPDES Storm Water Permitting Program

Storm water runoff is one of the remaining causes of contaminated lakes, streams, rivers, and estuaries throughout the country. Pollution in storm water runoff is responsible for closing beaches and shellfish harvesting areas, contaminating fish, and reducing populations of water plants and other aquatic life. High flows of storm water runoff cause flooding, property damage, erosion, and heavy siltation. The CWA requires EPA and States/Tribes to implement a national storm water control program to correct these problems. NPDES permits are currently required for storm water discharges from municipal separate storm sewer systems (MS4s) serving populations over 100,000, certain categories of industrial activities, and construction activity disturbing more than 5 acres. Revisions to the storm water regulations published December 8, 1999 (64 CFR 68722), will expand permit requirements to MS4s in urbanized areas serving populations under 100,000 and construction activity disturbing 1 to 5 acres.

### ■ Nonpoint Source Pollution

Under Section 319 of the CWA, States (*and Territories and approved Tribes*) address nonpoint source pollution by assessing nonpoint pollution problems and sources within the State, adopting management programs to control the nonpoint sources, and implementing the management programs. These programs may contain a variety of voluntary and regulatory approaches to controlling nonpoint source pollution. Section 319 also authorizes EPA to issue grants to the States to assist them in implementing EPA-approved nonpoint source management programs. Since 1990, EPA has issued \$1 billion in nonpoint source management grants to States, Territories, and Tribes. In fiscal year 2000, Congress appropriated \$200 million for the implementation of State programs.

The Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) required States with approved Coastal Zone Management Programs to develop and submit coastal nonpoint pollution control programs to EPA and the National Oceanic and Atmospheric Administration (NOAA) for approval. These State programs must include enforceable policies and mechanisms to ensure implementation of management measures for the control of nonpoint source pollution to restore and protect coastal waters. At their discretion, States may elect to include freshwater areas in their nonpoint pollution control programs. Section D of this chapter provides additional detail on nonpoint source pollution management programs.

### ***Step 5: Assessment of Controls***

Followup monitoring is an important step in the water quality–based approach. The following are among the key factors to consider when developing a followup monitoring plan:

- *Need to evaluate TMDL components.* TMDL problem identification, indicators, numeric targets, source estimates, and allocations might need reevaluation to determine whether they are accurate and effective.
- *Need to evaluate implementation actions.* It is often important to determine whether actions needed to achieve loading allocation were actually carried out and whether these actions were effective in achieving the allocations.

- *Stakeholder goals for monitoring efforts.* Watershed stakeholders often participate in followup monitoring, and their interests should be considered.
- *Existing monitoring activities, resources, and capabilities.* Analysts should identify existing and planned monitoring activities to address followup monitoring needs in concert with these efforts, particularly where a long-term monitoring program is envisioned, the study area is large, or water quality agency monitoring resources are limited. Staff capabilities and training also should be considered to ensure that monitoring plans are feasible.
- *Practical constraints to monitoring.* Monitoring options can be limited by practical constraints, such as problems with access to monitoring sites and concerns about indirect impacts of monitoring on habitat.

The role of nutrient criteria in followup monitoring is as follows:

- Nutrient criteria will provide the measure of success for controls.
- Process may need to be revisited if followup monitoring and reference condition calibration indicate criteria should be revised.
- Process may need to be revisited if followup monitoring indicates designated uses should be revised.

### **C. Nonpoint Source Pollution Management**

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. Technically, the term "nonpoint source" is defined to mean any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the CWA. That definition states:

The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

Although diffuse runoff is generally treated as nonpoint source pollution, runoff that enters and is discharged from conveyances such as those described above is treated as a point source discharge and hence is subject to the permit requirements of the CWA. In contrast, nonpoint sources are not subject to Federal permit requirements.

Nonpoint pollution is the pollution of our Nation's waters caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural pollutants and pollutants resulting from human activity, finally depositing them into lakes, rivers, wetlands, coastal waters, and ground waters. In addition, hydrologic modification is a form of nonpoint source pollution that often adversely affects the biological and physical integrity of surface waters. A more detailed discussion of the range of nonpoint sources and their effects on water quality and riparian habitats is provided in subsequent chapters of this guidance.

## ***1. Guidance for Controlling Nonpoint Sources of Nutrients***

*Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (EPA, 1993) was developed by EPA for the planning and implementation of Coastal Nonpoint Pollution Programs. The guidance focuses on controlling five major categories of nonpoint sources that impair or threaten waters nationally, and provides useful guidance for nonpoint source pollution management in both coastal and noncoastal areas. Management measures are specified for (1) agricultural runoff, (2) urban runoff (including developing and developed areas), (3) silvicultural (forestry) runoff, (4) marinas and recreational boating, and (5) channelization and channel modification, dams, and streambank and shoreline erosion. EPA also includes management measures for wetlands, riparian areas, and vegetated treatment systems that apply generally to various categories of sources of nonpoint pollution. Management measures are defined in the CZARA as economically achievable measures to control the addition of pollutants to waters, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives.

The following section outlines some of the management measures specified in the CZARA guidance for the various types of nonpoint sources. These measures should be considered when implementing programs targeting nutrient releases into waters of the U.S. Information on specific management practices is available in *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (EPA, 1993).

### **■ Agricultural Runoff**

- Erosion and sediment control
- Control of facility waste water and runoff from confined animal facilities
- Nutrient management planning on cropland
- Grazing management systems
- Irrigation water management

### **■ Urban Runoff**

- Control of runoff and erosion from existing and developing areas
- Construction site runoff and erosion control
- Construction site chemical control (includes fertilizers)
- Proper design, location, installation, operation, and maintenance of onsite disposal systems
- Pollution prevention education (e.g., household chemicals, lawn and garden activities, golf courses, pet waste, onsite disposal systems)
- Planning, siting, and developing roads, highways, and bridges (including runoff management)

### **■ Silvicultural Runoff**

- Streamside management
- Road construction and management
- Forest chemical management (includes fertilizers)
- Revegetation
- Preharvest planning, harvesting management

## ■ **Marinas and Recreational Boating**

- Sting and design
- Operation and maintenance
- Storm water runoff management
- Sewage facility management
- Fish waste management
- Pollution prevention education (e.g., proper boat cleaning, fish waste disposal, and sewage pump out procedures)

## ■ **Hydromodification** (i.e., channelization, channel modification, dams)

- Minimize changes in sediment supply and pollutant delivery rates through careful planning and design
- Erosion and sediment control
- Chemical and pollutant control (includes nutrients)
- Stabilization and protection of eroding streambanks or shorelines

## ■ **Wetlands, Riparian Areas, Vegetated Treatment Systems**

- Protect the NPS abatement and other functions of wetlands and riparian areas through vegetative composition and cover, hydrology of surface and ground water, geochemistry of the substrate, and species composition
- Promote restoration of preexisting function of damaged and destroyed wetlands and riparian systems
- Promote the use of engineered vegetated treatment systems where they can serve a NPS pollution abatement function

## **2. *Nonpoint Source Management Programs***

In 1987, in view of the progress achieved in controlling point sources and the growing national awareness of the increasingly dominant influence of nonpoint source pollution on water quality, Congress amended the CWA focus greater national efforts on nonpoint sources. In the Water Quality Act of 1987, Congress amended Section 101, “Declaration of Goals and Policy,” to add the following fundamental principle:

It is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution.

More importantly, Congress enacted Section 319 of the CWA, which established a national program to control nonpoint sources of water pollution. Under Section 319, States address nonpoint pollution by assessing nonpoint source pollution problems and causes within the State, adopting management programs to control the nonpoint source pollution, and implementing the management programs. Although not required, many States have incorporated the management measures specified in the 1993 CZARA guidance into their State Nonpoint Source Management Programs.

Section 319 also authorizes EPA to issue grants to States to assist them in implementing those management programs or portions of management programs that have been approved by EPA. Since 1990, \$876.5 million dollars in grants have been given to States, Territories, and Tribes for implementation of nonpoint source pollution control programs.

For additional information on the Nonpoint Source Management Program and distribution of Section 319 grants in your State, contact your State's designated nonpoint source agency. For many states, the nonpoint source agency is the State Water Quality Agency. However, in several instances, other agencies or departments are given nonpoint source responsibility (see Table 8.1).

**Table 8.1. States for Which the Nonpoint Source Agency Is Not the Water Quality Agency**

State	State Nonpoint Source Agency
Arkansas	State Department of Soil and Water Conservation
Delaware	State Department of Soil and Water Conservation
Oklahoma	State Department of Soil and Water Conservation
Pennsylvania	State Department of Soil and Water Conservation
Tennessee	State Department of Agriculture
Texas	Department of Soil and Water Conservation (for agriculture) Texas Water Quality Board (all other nonpoint sources)
Virginia	State Department of Soil and Water Conservation

### ***3. Coastal Nonpoint Pollution Control Programs***

In November 1990, Congress enacted the CZARA. These amendments were intended to address several concerns, a major one of which is the impact of nonpoint source pollution on coastal waters.

To address more specifically the impacts of nonpoint source pollution on coastal water quality, Congress enacted Section 6217, "Protecting Coastal Waters," which was codified as 16 USC-1455b. This section provides that each State with an approved coastal zone management program must develop and submit to EPA and the NOAA for approval a Coastal Nonpoint Pollution Control Program. The purpose of the program "shall be to develop and implement management measures for nonpoint source pollution to restore and protect coastal waters, working in close conjunction with other State and local authorities." States determine how far "upstream" their coastal zone management program applies; in some instances, the entire State is covered in a comprehensive attempt to merge coastal zone management and nonpoint source pollution management.

States and Territories with Coast Nonpoint Pollution Control Programs may elect to implement alternative management measures as long as the alternative measures will achieve the same environmental results as those described in the 1993 CZARA guidance, as discussed previously. A listing of States with Coastal Nonpoint Pollution Control Programs is presented in Table 8.2. For additional information on the programs in these States, contact the State water quality agency.

**Table 8.2. States and Territories with Coastal Nonpoint Pollution Control Programs**

Alabama	Maine	Oregon
Alaska	Maryland	Pennsylvania
American Samoa	Massachusetts	Puerto Rico
California	Michigan	Rhode Island
Connecticut	Mississippi	South Carolina
Delaware	New Hampshire	Virgin Islands
Florida	New Jersey	Virginia
Guam	New York	Washington
Hawaii	North Carolina	Wisconsin
Louisiana	Northern Mariana Islands	

#### **4. Farm Bill Conservation Provisions**

Technical and financial assistance for landowners seeking to preserve soil and other natural resources is authorized by the Federal Government under provisions of the Food Security Act (Farm Bill). Provisions of the 1996 Farm Bill relating directly to installation and maintenance of BMPs are summarized in the following sections. For State-specific information, contact your NRCS State Conservationist's office.

##### **■ Environmental Conservation Acreage Reserve Program (ECARP)**

ECARP is an umbrella program established by the 1996 Farm Bill that contains the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), and Environmental Quality Incentives Program (EQIP). It authorizes the Secretary of Agriculture to designate watersheds, multi-State areas, or regions of special environmental sensitivity as conservation priority areas that are eligible for enhanced Federal assistance. Assistance in priority areas is to be used to help agricultural producers comply with NPS pollution requirements of the CWA and other State or Federal environmental laws. The ECARP is authorized through 2002.

##### **■ Conservation Reserve Program (CRP)**

First authorized by the Food Security Act of 1985 (Farm Bill), this voluntary program offers annual rental payments, incentive payments, and cost-share assistance for establishing long-term, resource-conserving cover crops on highly erodible land. CRP contracts are issued for a duration of 10 to 15 years for up to 36.4 million acres of cropland and marginal pasture. Land can be accepted into the CRP through a competitive bidding process where all offers are ranked using an environmental benefits index, or through continuous sign-up for eligible lands where certain special conservation practices will be implemented.

The Conservation Reserve Enhancement Program (CREP) is a new initiative of CRP authorized under the 1996 Federal Agricultural Improvement and Reform Act. CREP is a joint, State–Federal program designed to meet specific conservation objectives. CREP targets State and Federal funds to achieve shared environmental goals of national and State significance. The program uses financial incentives to encourage farmers and ranchers to voluntarily protect soil, water, and wildlife resources.

#### ■ **Wetlands Reserve Program (WRP)**

The WRP is a voluntary program to restore and protect wetlands and associated lands. Participants may sell a permanent or 30-year conservation easement or enter into a 10-year cost-share agreement with USDA to restore and protect wetlands. The landowner voluntarily limits future use of the land, yet retains private ownership. The Natural Resources Conservation Service (NRCS) provides technical assistance in developing a plan for restoration and maintenance of the land. The landowner retains the right to control access to the land and may lease the land for hunting, fishing, and other undeveloped recreational activities.

#### ■ **Environmental Quality Incentives Program (EQIP)**

The EQIP was established by the 1996 Farm Bill to provide a voluntary conservation program for farmers and ranchers who face serious threats to soil, water, and related natural resources. EQIP offers financial, technical, and educational help to install or implement structural, vegetative, and management practices designed to conserve soil and other natural resource. Current priorities for these funds dictate that one half of the available monies be directed to livestock-related concerns. Cost-sharing may pay up to 75% of the costs for certain conservation practices. Incentive payments may be made to encourage producers to perform land management practices such as nutrient management, manure management, integrated pest management, irrigation water management, and wildlife habitat management.

#### ■ **Wildlife Habitat Incentives Program (WHIP)**

This program is designed for people who want to develop and improve wildlife habitat on private lands. Plans are developed in consultation with NRCS and local Conservation District. USDA will provide technical assistance and cost-share up to 75% of the cost of installing the wildlife practices. Participants generally must sign a 5- to 10-year contract with the U.S. Department of Agriculture (USDA), which requires that they maintain the practices.

#### ■ **Forestry Incentives Program (FIP)**

Originally authorized in 1978, the FIP allows cost sharing up to 65% (up to a maximum of \$10,000 per person per year) for tree planting, timber stand improvement, and related practices on nonindustrial private forest land. The FIP is administered by NRCS and the U.S. Forest Service. Cost share funds are restricted to individuals who own no more than 1,000 acres of eligible forest land.

#### ■ **Conservation of Private Grazing Land**

This program was authorized by the 1996 Farm Bill for the purpose of providing technical and educational assistance to owners of private grazing lands. It offers opportunities for better land management, erosion reduction, water conservation, wildlife habitat, and improving soil structure.

## **D. A Comprehensive Procedure for Nutrient Management**

In addition to regulatory assessment and source control, criteria can serve as effective scientific tools for holistic resource management. Effective programs incorporate aspects of prevention and maintenance as well as restoration. It is important that existing high-quality waters be managed wisely as a public resource and that waters whose uses are not yet threatened or impaired, but nonetheless are at risk from ongoing pollution, are identified and managed such that beneficial uses are maintained in the future. Below is a generic 10-step management program that originated with the Wisconsin Inland Lakes Program (Gibson et al., 1983) and has been subsequently refined as a natural resources management approach. States and Tribes can use this procedure in addition to their established regulatory protocols. This approach is intended to illuminate useful steps to take to ensure responsive management; it is not intended to establish or mandate any procedures as part of a regulatory requirement.

Management of lakes and reservoirs may be approached in a rational progression of actions beginning with a statement of their major stressors and symptoms and progressing logically to a course of action and final assessment to determine the relative success of the effort. The following sequence of steps is one illustration of this management approach. States or communities are encouraged to adapt this technique to suit their particular needs and expectations. Where considerable information is already available, some of these steps may be unnecessary, but the methodology is presented here for consideration.

### ***1. Status Identification***

Data used during the preliminary nutrient criteria development process and the application of the criteria will present the resource manager with an image of the general status of a lake/reservoir and the degree of need for responsive action. The information associated with these efforts, however, usually indicates a broad status condition, for example, high nutrient concentrations, algal blooms, fish kills, or low dissolved oxygen. Available data should be evaluated carefully to tease out potential relationships with land use practices or recent changes in practices (e.g., fishing pressure, stocking or lack thereof). In particular, previous investigations should be reviewed to make a preliminary determination of anthropogenic cause(s) versus natural cycling of the lake or reservoir. Essentially, one needs to conduct a preliminary evaluation of readily available or on-hand lake or reservoir data to ascertain that there is indeed a problem or potential problem of cultural overenrichment and that these sources probably can be addressed to the betterment of the water body and the public good.

### ***2. Background Investigation***

Given that the initial information reveals a viable management concern, it then becomes necessary and justifiable to gather as much background information as possible about the water body in question. There are three primary sources of such information.

#### **■ Literature Searches**

The initial effort here should be the “gray literature” (often internal regional State and Federal agency reports that provide specific information about that lake). Sources of such information include natural resource and fisheries agencies, forestry services, water quality administrations, hydrological and geological survey offices, planning offices, multi-State or county commissions, and community or environmental groups. A second source would be peer-reviewed professional literature—journals and related publications such as proceedings of conferences and symposiums, which may include specific

studies of the lake or reservoir of concern. But their primary value probably will be discussions of methods and techniques of investigation and management. As the management investigation progresses, these sources of information become more pertinent.

## ■ Questionnaires

In preparing a list of agencies from which reports may be solicited, the names of key personal contacts also should evolve. These contacts are the biologists, chemists, specialists, academics and resource managers, and citizen activists most familiar with the lake(s) of concern. As the literature and baseline data are reviewed, particular questions should develop, the answers to which will provide a fuller understanding of the resource and lend direction to the investigation and eventual management plan. Particularly helpful will be an understanding of the historical antecedents of the present status of the lake or reservoir.

A standardized questionnaire can be prepared listing concerns such as the availability of any reports or data or understanding of the history of development in the watershed, perhaps including industries, agricultural practices, or development and structures associated with the lake. Particular episodes may be noted for comment in the questionnaire, such as fish kills, algal blooms, or spill events, as well as historical problems, such as septic tank problems, agricultural runoff, erosion problems, or development concentrations.

All discharge sites should be documented, such as waste water treatment plants, drains, concentrations of cottages with onsite waste water treatment, marinas, major road crossings, and tributaries potentially bearing loadings of sediments or nutrients. Problem land use areas along the shore also should be noted, for example, degraded wetlands, lobes of the lake or reservoir where blooms or fish kills regularly occur, or areas where aquatic macrophytes have recently expanded or contracted. In addition, it is helpful to include a large, fairly detailed line drawing of the lake/reservoir and its watershed that the respondent may use to locate and identify particular observations.

If at all possible, the questionnaire should be limited to no more than two pages of questions, including space for answers plus the line drawing. Questions should be direct and concise. Determine exactly what you wish to learn and ask questions specifically related to this information. Opportunities for additional comments should be restricted to one open question at the end of the questionnaire.

To get the best response to a questionnaire, the potential respondents should be called first to confirm the names on the mailing list. They should be advised of the nature of the study and their cooperation then requested. Other potential respondents may be identified through these calls. If a large survey is necessary, this preliminary step may not be possible. However, most such regional inquiries are usually to no more than 50 specialists, and the additional information gained is well worth the telephone calls.

## ■ Interviews

By this point in the background investigation process, the key people to contact for detailed information should be evident. Their names will have come up in conversations and on reports, and they will be the people providing the most helpful responses on the questionnaires.

Other valuable contacts are the USDA Cooperative Extension Service agents for the counties in which the lake/reservoir is situated, county planners, and long-term residents and fishermen of the area. Their anecdotal information can be invaluable and helps add perspective to other sources of data.

The basis for the interviews should be to assess the questionnaire data already gathered. The interviews should clarify and elaborate on basic information generated by the questionnaire. The interview is also the means by which apparent contradictions in perceptions or observations may be at least partially resolved. It should be noted that many people are uncomfortable with recorded interviews; note-taking is often a more complimentary and less intimidating way to record information. In any case, immediately after each interview, a record of answers and observations should be prepared while the impressions of the interview are still fresh.

The compiled information from the background investigation will further clarify the initial problem statement. It should help resolve any ambiguities about the dynamics of the lake/reservoir and the human community. In addition, it should clearly define areas where more definitive, primary data collection is required to clearly understand the nutrient problems of that particular water body and provide direction for the subsequent management project.

### ***3. Data Gathering and Diagnostic Monitoring***

Data obtained during the nutrient criteria development process is the mainstay of the database to be prepared for any subsequent investigation. The intent of that survey was to develop a reasonable image of the status of the lake/reservoir. Diagnostic monitoring should expand on that structure and extend the understanding from status of the resource to a diagnosis of causes of the overenrichment. For example, where three reaches of a lake/reservoir may have been sampled and two identified as being of concern, now the tributaries and other higher order streams must be sampled to further reduce the area to locations of probable loadings. While earlier sampling was to portray the trophic state of the lake or reservoir, these sample sites should be directed specifically toward near-shore areas of potential loadings, tributaries, and portions of the tributaries where loadings may originate.

Diagnostic monitoring supports the identification of water quality problems and helps to develop an appropriate management plan. General guidelines for conducting diagnostic monitoring are provided below.

#### **■ Parameters To Sample**

Diagnostic monitoring is conducted after nutrient criteria have been established. It might not be necessary, therefore, to sample some parameters that are not related to the criteria.

Diagnostic sampling for nutrients requires an estimation of nutrient loading and sources. Major potential sources of nutrients (e.g., tributary streams, ground water flow, runoff, illegal discharges, atmospheric deposition) should be identified and sampled in such a way as to obtain an estimate of annual loads from each source. For methods and design considerations, see Olem and Flock (1990) and Wedepohl et al. (1990).

The variables and techniques employed in the preliminary survey should be reviewed for adequacy and either repeated or augmented. The manager should not eliminate the basis of the original classification by dropping any variables or stations at this point. Documenting potential success or failure of the subsequent management program will require “before” and “after” databases, and the initial survey design should be modified only after careful consideration and due attention to reestablishing the baseline survey.

Flow measurements are also an essential part of this survey. If nutrient concentrations are to be meaningfully compared and loading estimates made, cross-sectional areas and flow rates for all tributary streams and discharges must be included in the survey design. These measurements must be made or extrapolated each time water quality samples are collected. Without this information, it will be difficult or impossible to assign priorities to various loading sources identified in the investigation.

### ■ Sampling Frequency

Sampling frequency will increase for diagnostic monitoring because the sample population is now an individual lake. Sampling should occur repeatedly during the growing season to be able to precisely characterize individual lakes as well as discharges and loadings. Statistical power analysis can be used to determine the appropriate sample size based on the purpose of the sampling and the acceptable error (see Chapter 9).

In addition to expanding the number of stations and parameters to accommodate diagnostic determinations, the survey design should address the temporal variable by sampling these stations during each season of the year at times calibrated to that particular climate and locale. Accommodation may need to be made for periods of base flow, maximum runoff, turnovers, periods of maximum and minimum productivity, and, in some instances, migratory patterns of fish or waterfowl. Seasonal changes in land use such as peak summer or winter vacation periods, agricultural applications and harvests in the watershed, and seasonal commercial or industrial activities also should be addressed.

To separate signals from seasonal noise, it may be necessary to gather survey data for 2 or more consecutive years to strengthen data assessments. Such assessments will require a robust statistical evaluation of the data; this element should be incorporated into the study design at the outset. As with the initial survey design, the preliminary statistical tools chosen may be carried into this subsequent design as well. Care should be taken to address the need for replicate sample collections to ensure representative sample design and confidence in the results to be obtained. Early inclusion of a skilled environmental statistician on the management team is advisable.

### ■ Sampling Location

If turbidity, nutrients, and algae are known to be variable across the surface of a lake, then multiple sample sites are required. If gradients are known to occur, as in many large reservoirs, then sampling should be stratified by zones. For example, in a reservoir one could define the three reservoir zones (riverine, transitional, lacustrine) as sampling strata and take two or more samples from each zone.

The exact number of sampling sites in a lake or lake zone is determined by the spatial variability of nutrients, turbidity, and chlorophyll and the desired precision. In general, within a basin or reservoir zone, variation in time is larger than variation in space (Knowlton and Jones, 1989). Thus, chlorophyll samples taken 2 weeks apart may differ by severalfold, but samples taken on the same day 500 meters apart are likely to differ much less. Depending on the questions being addressed in the investigation, spatially composite samples may be more cost-effective than separate samples from several sites in a lake (see Olem and Flock [1990] and Wedepohl et al. [1990]).

The design and placement of these sample stations will rely heavily on the land use information developed from the background investigation. The overall premise should be to bracket suspected sources of nutrient loadings in the tributaries and near-bank areas so parcels can be either selected or eliminated as potential candidates for management attention.

#### ***4. Source Identification***

The cumulative information gathered should now provide a clear image of the state of the lake or reservoir, the most likely sources of nutrient loadings or related degradation, and their relative contributions to the problem. It is important to note that this process reveals only local sources of the overenrichment. Atmospheric deposition of nitrogen compounds and other broad-scale impacts beyond the watershed scale are not specifically addressed and must be assumed as essentially an environmental constant. With all the risks this entails, it is probably not an undue assumption, because such remediation is probably beyond the scope of most nutrient management projects employing this guidance.

The problems to be identified are likely to be as diverse as the geology, hydrology, and land use practices of the lake/reservoir and watershed. Typical elements include sediment resuspension and nutrient re-release; biotic imbalances affecting nutrient utilization by overfishing or stock mismanagement; discharge of excess nutrients directly to the lake or reservoir by waste water treatment plants, storm water runoff, or failing septic systems; and runoff from subdivisions, farms, logging operations, golf courses, and shopping centers. Other problems have included concentrations of migratory and resident waterfowl contributing to an excess of nutrients, removal or filling of bank areas and wetlands that once intercepted nutrient runoff, herbicide applications that killed macrophytes and promoted nuisance algal blooms, and chronic low dissolved oxygen problems attendant to overenrichment and vegetative imbalances.

Any combination of these in situ and land use problems are potential causes of the cumulative overenrichment problem. Management planning requires identifying first the loading sources and, second, of those sources, the ones that are most significant. Proximity of a source to the lake or reservoir (or in some cases, the ubiquitous nature of a source throughout the watershed such as subdivision or farm runoff), the relative loading estimate of that source, and the likelihood of successful remediation are the key factors in deciding which problem sources are priorities for inclusion in a management plan.

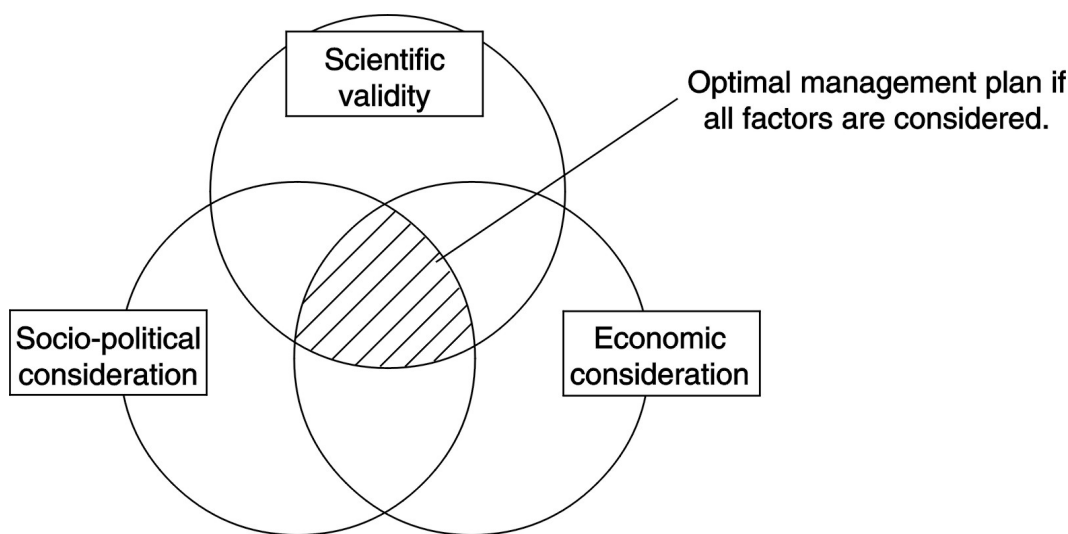
Loading estimation models such as those developed by Vollenweider and by Dillon and Rigler, the Reckhow-Simpson model, and BATHTUB by Walker are valuable for estimating the relative significance of various nutrient sources in the watershed with respect to the likely response of the lake. Chapter 9 describes many of these models and their relative utility. Modeling permits the manager to try out various preliminary management scenarios and combinations of management techniques to estimate their likely effectiveness. Some of these options for consideration in a lake nutrient management plan are discussed in the next step.

#### ***5. Management Practices for Nutrient Control***

Once the major sources of concern are identified and agreed on by the management planners, remedial measures appropriate to these sources must be identified. Management practices are well defined and documented for a variety of land uses in EPA guidance documents, USDA manuals, U.S. Forest Service manuals, and urban land use planning guides. The resource manager should study these references for likely approaches to consider and then consult regional experts in each of the subject land uses for qualification and other suggested management practice recommendations. Bringing these specialists together as a small workgroup is an effective, although sometimes contentious, way to develop the most technically sound approaches to these chosen problems.

Fitting the various components together in a comprehensive management plan is challenging. It calls for both imagination and a sense of cooperation. Usually no one approach stands out as the obvious best choice. Instead, two or three permutations of several generally agreed on BMPs will evolve from the planning sessions.

Selection of the optimal approach—or more likely, the best candidates—should first involve a careful assessment by the planning workgroup and then consultation with all elements of the watershed community, both organized interest groups and private landowners. The first phase of this selection process should include review by a threefold framework of evaluation. This approach was developed by the Department of Resource Development at Michigan State University (Figure 8.2) The premise behind this approach is essentially that the most effective and achievable management plan should be able to address three elements of practicality:



**Figure 8.2. “Threefold framework” of evaluation.**

- No resource or environmental management plan should even be considered unless it is scientifically valid. The technology proposed should be based in sound science and tested and validated. No attempt to manipulate the environment and peoples’ land use prerogatives should be made unless it can be demonstrated in advance that the technique is reliable or at least that the risks are quantifiable and understandable.
- The approach proposed should be cost-effective and affordable by the community. EPA has a series of economic tests that can be applied to standards development that can be adapted to management planning for a similar result. Among technically sound plans to achieve desired goals, the most cost-effective plans (typically those with elements that have the greatest benefit-cost ratios) are most likely the easiest to implement and the most likely to satisfy the public interest.
- The management plan should have an adequate degree of social and political acceptability. That which is eminently rational and cost-effective may conflict with the collective values of most of the local public. This is particularly important if taxing or regulatory actions are part of the management plan. Any form of regulation or permit action taken in addition to existing requirements should always be carefully researched through the responsible local, State, and

Federal agencies as to the justification, efficacy, lead time required, and likely effects on various segments of the community.

The resource manager most likely to achieve success will consider and responsibly address each of these three elements. All candidate alternatives should be evaluated in this manner and revised as necessary. This not only generates the optimal plan (or plans where competing but different strengths are evident), but it documents the rationale for that decision essential to public review before the final selection is made.

Involving the public in the process throughout is highly beneficial, and meetings or advisories to all potentially interested parties should be regularly provided, if not from the outset of the availability of definitive data, then certainly before the time when plan selection and approval are needed. A balance in public information must be struck between making announcements too early, which may needlessly arouse people before sufficient information has been generated, and making announcements too late, which may lead to suspicions of keeping the public in the dark.

## ***6. Detailed Management Plan***

A detailed management plan should include all 10 steps of the process described here. The first five steps are necessary to get to the design of the plan, but they should also be included so that anyone reading it will understand what has gone into the effort.

Natural resource management efforts can include these three elements: education, financing, and regulation. Any resource management tool will fall into one of these broad categories, and it is good to try to initiate the various techniques in the same order as they are presented here. First, you should start with relatively low-cost information and education efforts to acquaint people with the problem and how you propose to address it—and not coincidentally, to get their suggestions and perceptions of the issue and approach. A good educational effort should be the incentive for volunteer agreements and cooperative action. A grant-in-aid or other assistance is often the key element necessary to further encourage individuals to adopt appropriate local lake protection practices. Regulatory actions are necessary and appropriate when mandated by law, where cooperation and compliance are unlikely to occur otherwise, and when voluntary efforts have clearly not been successful.

## ***7. Implementation and Communication***

In addition to the discussion about communication above, the progress review periods during the management project are opportunities to provide reports to administrators, other involved agencies, politicians interested in the project, the general public and landowners, and other interest groups. Such reports should be brief and candid. They will be part of the public record so all parties are properly informed, help avoid the postproject cry of not being adequately advised of what was going on, and document the techniques and methods used for future consideration.

Regional public meetings and hearings are an excellent way to accomplish this communication. The more controversial an issue, the more this is necessary and the more important it is to listen carefully to the responses and to objectively weigh appropriate adjustments to the plan. To charge ahead in the face of significant opposition without evaluating the consequences is folly. This is especially true if a change to a stepwise approach in the management plan with additional public consultation would still achieve the same objective.

## **8. *Evaluation Monitoring and Periodic Review***

The management plan should always include “before,” “during,” and “after” water resource quality monitoring to demonstrate the relative response of the system to management efforts. This is why the initial survey stations should generally be maintained and expanded. Such monitoring data are important as a benchmark for evaluating progress and are an important component in the requisite progress reports described above. The change or lack thereof of the lake or reservoir is the ultimate determination of management success.

These built-in monitoring schedules should include seasonality and periodic data assessment intervals for management review to permit responses to changing circumstances, modifications of methods, schedules, and changes of emphasis as needed.

## **9. *Completion and Evaluation***

Management projects are frequently planned, initiated, and concluded, with new initiatives undertaken to meet pressing schedules, without sufficiently evaluating what was initially accomplished.

Review of the progress reports, of the original objectives, and of the monitoring data will reveal whether the lake or reservoir trophic state was successfully protected or improved. Just as important, this evaluation provides the documentation necessary to determine if methods and techniques attempted in this instance can be applied elsewhere, perhaps with modification. Alternatively, it will also reveal if mistakes were made that should be noted and avoided in future projects and perhaps that a sequel project is required to fully accomplish the original objectives.

## **10. *Continued Monitoring of the System***

The database initiated and expanded in the course of the project can now be reduced to the periodic measuring of key variables at critical times and locations. The purpose now is to keep sufficiently informed of the status of the lake or reservoir to ensure that the protection or remediation achieved is maintained. If periodic evaluation monitoring indicates a return of trophic decline, intervention should be possible at an early point so that costs of preserving that which was achieved are reduced. The evaluation and periodic monitoring steps of this process essentially close the loop. If new issues arise, the manager returns to step one with a new problem statement. General guidelines associated with evaluation monitoring are provided below.

### **■ Parameters To Sample**

Each of the water quality parameters discussed in the Indicators chapter (i.e., TP, TN, chlorophyll, Secchi depth, and dissolved oxygen) should be sampled during maintenance monitoring. Because the purpose of maintenance monitoring is to determine if conditions change or if criteria are exceeded, other physical or chemical variables need not be measured.

### **■ Sampling Frequency**

Sampling efforts for maintenance monitoring can be adaptive and sequential, so that a certain minimum of information is collected at regular intervals, and if data indicate change or uncertainty, the sampling effort (in both time and space) can be increased to attempt to reduce the uncertainty. For example, a lake in an undisturbed area could be sampled once every 5 years, from a single visit during an

index period (say, spring turnover). If results suggest a change in lake conditions beyond what is normally expected for a lake of its class, then additional sampling of the lake can be continued to determine if the departure from “normal” conditions is real and if it is ecologically significant. If TP, TN, chlorophyll *a*, and Secchi depth relationships have been established, it may be cost-effective to use Secchi depth as a preliminary indicator; if a trigger value is detected, more parameters would be measured.

This also suggests different levels of maintenance monitoring, depending on existing knowledge of a lake and expectations. Maintenance monitoring may be done for several purposes:

- Routine monitoring of a lake of known quality (i.e., has been sampled before) that is not expected to change greatly
- Initial sampling of a lake of unknown quality
- Monitoring of a lake of known quality that is expected to change, as with watershed development or following restoration efforts

Routine monitoring of lakes of known quality is the least intensive and would typically require sampling once every several years, as in the example above. Initial sampling of a lake of unknown quality requires the same sampling effort, and parameters, as the classification survey. Monitoring a known lake that is expected to change or suspected to have changed requires more intensive effort, typically an increase in sampling frequency to several times during the growing season to obtain seasonal averages of indicator values.

The actual frequency of sampling should be determined by the number of samples required to detect an ecologically relevant change in the indicators of a single lake, resources available for the monitoring program, and amount of time for a change to be detected. These considerations require power analysis using existing or preliminary data (see Chapter 9), and tradeoffs of desired significance level, desired power, desired effect size that is detectable, ecological significance, and most important, resources (labor and money) available for the monitoring program.

## ■ Sampling Location

For routine monitoring, it is recommended that the sampling locations be the same as for the classification survey, whether a single midlake site, a spatially composite sample, or separate sampling sites within a lake.

## E. Resources

Listed below are selected publications concerning lake and watershed management and protection.

- *Cooke, GD; Welch, EB; Peterson, SA; Newroth, PR. 1993. Restoration and management of lakes and reservoirs, 2nd ed. Boca Raton: Lewis Publishers.*  
This book is a current description of effective in-lake management techniques and approaches. It is an extensive account of the state of the art and science of in-basin lake management techniques.

- *Sharpley, AN (ed). 2000. Agriculture and phosphorus management: the Chesapeake Bay. Boca Raton: Lewis Publishers*  
 This text is a compilation of conference proceedings describing nutrient dynamics in the watershed of Chesapeake Bay with emphasis on agricultural loadings and practices. Although directed at an estuarine environment, much of the agriculturally based nutrient information has broad application.
- *U.S. Environmental Protection Agency. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. (EPA-840-B-92-002)*  
 The EPA Office of Water produced the 1993 guidance document to support the Coastal Zone Act Reauthorization Amendments of 1990. This document describes several management measures to control nonpoint sources of pollution, including nutrients.
- *U.S. Environmental Protection Agency. 1990. Monitoring lake and reservoir restoration: technical supplement to lake and reservoir restoration guidance manual. (EPA-440/4-90-007)*  
 This document focuses on effective water quality monitoring techniques to assess status and trends of inland lakes and reservoirs. It was prepared by a panel of highly experienced State lake management specialists and emphasizes practical and cost effective measurement techniques.
- *U.S. Environmental Protection Agency. 1995. Watershed Protection: A Project Focus (EPA 841-R-95-003)*  
 This document focuses on developing watershed-specific programs or projects. It provides a blueprint for designing and implementing watershed projects, including references and case studies for specific elements of the process. The document illustrates how the broader principles of watershed management—including all relevant Federal, State, Tribal, local, and private activities—can be brought to bear on water quality and ecological concerns.
- *U.S. Environmental Protection Agency. 1995. Watershed Protection: A Statewide Approach (EPA 841-R-95-004)*  
 This document is primarily designed for State water quality managers. A common framework for a statewide watershed approach focuses on organizing and managing a State's major watersheds (called basins in this document). In this statewide approach, activities such as water quality monitoring, planning, and permitting are coordinated for multiple agencies on a set schedule within large watersheds or basins.
- *U.S. Environmental Protection Agency. 1997. Monitoring Consortia: A Cost-Effective Means to Enhancing Watershed Data Collection and Analysis (EPA 841-R-97-006)*  
 This document addresses coordination in watershed monitoring. As demonstrated in the document's four case studies, consortia can stretch the monitoring dollar, improve cooperation among partners, and increase sharing of expertise as well as expenses of data collection and management.
- *U.S. Environmental Protection Agency. 1997. Land Cover Digital Data Directory for the United States (EPA 841-B-97-005)*  
 Land cover, which is the pattern of ecological resources and human activities dominating different areas of the earth's surface, is one of the most important data sources used in watershed analysis and the management of water resources throughout the country. The 75 land cover data summaries in this directory include contact information to assist readers who may want to acquire copies of the digital data for their own use.

- *U.S. Environmental Protection Agency. 1997. Designing an Information Management System for Watersheds* (EPA 841-R-97-005)

This document is an introduction to the information management responsibilities and challenges facing any watershed group. The document reviews the fundamentals of identifying information management needs, integrating different databases, evaluating hardware and software options, and developing implementation plans.
- *U.S. Environmental Protection Agency. 1997. Information Management for the Watershed Approach in the Pacific Northwest* (EPA 841-R-97-004)

This document centers on a series of interviews with leaders and key participants in the statewide watershed approach activities in the State of Washington. The document reviews Washington's statewide watershed activities in case study fashion.
- *U.S. Environmental Protection Agency. 1998. Inventory of Watershed Training Courses* (EPA 841-D-98-001)

This inventory provides one-page summaries of 180 watershed-related training courses offered by Federal and State agencies; it also lists resource professionals in the private sector.
- *U.S. Environmental Protection Agency. 1997. Statewide Watershed Management Facilitation* (EPA 841-R-97-011)

This document addresses statewide watershed management and the process of facilitating the development or reorientation of statewide watershed programs. It includes state case histories.
- *U.S. Environmental Protection Agency. 1996. Watershed Approach Framework* (EPA 840-S-96-001)

This publication revisits and updates EPA's vision for a watershed approach, first explained in a 1991 document entitled "Watershed Protection Approach Framework." It describes watershed approaches as coordinating frameworks for environmental management that focus public and private efforts to address the highest priority problems defined geographic areas, involving both ground and surface water flow.
- *U.S. Environmental Protection Agency. 1997. Top 10 Watershed Lessons Learned* (EPA 840-F-97-001)

Watershed work has been going on for many years now, and this 60-page document summarizes the top lessons that have been learned by watershed practitioners across the United States regarding what works and what does not.
- *U.S. Environmental Protection Agency. 1999. Catalog of Federal Funding Sources for Watershed Protection (second ed.)* (EPA 841-B-99-003)

Many sources of Federal funding are available to support different aspects of watershed protection and specific types of local-level watershed projects. This document presents information on 52 Federal funding sources (grants and loans) that may be used to fund a variety of watershed projects.
- *U.S. Environmental Protection Agency. 1997. Watershed Training Opportunities* (EPA 841-B-97-008)

This is a 22-page booklet developed to highlight watershed training opportunities offered by EPA's Office of Water and the Watershed Academy. It covers training courses and educational materials on watersheds produced throughout the EPA Office of Water.

- *U.S. Environmental Protection Agency. 1997. Stream Corridor Restoration: Principles, Processes and Practices* (EPA 841-R-97-011)  
This document is a practical reference manual and logical framework to help environmental managers recognize stream restoration needs and design and implement restoration projects.
- *U.S. Environmental Protection Agency. 1997. Protocol for Developing Nutrient TMDLs* (EPA 841-B-99-007)  
This protocol is an organizational framework for the TMDL development process for nutrients. It leads to an understandable and justifiable TMDL.